Amendments to the Specification

A new paragraph has been added to page 1 before line 5.

This application is a division of Application No. 10/078,438 filed February 21, 2002.

The paragraph starting at page 1, line 25 has been amended as follows.

Of these serial recording apparatuses, the ink jet type records an image by spraying ink directly onto the recording medium, and has the advantage of low ~~running~~ operating costs and ~~little~~ low noise during recording. Additionally, in the ink jet system of image recording, a certain distance is maintained between the recording head and the recording medium, such that, typically, the two do not contact each other and the ink sprayed from the recording head crosses the space between the recording head and the recording medium so as to reach the recording medium and ~~so~~ form a desired image. As a result, the frictional load of the carrier on which the printing head is loaded and scanned can be reduced, making it possible to achieve high printing speeds.

The paragraph starting at page 5, line 26 has been amended as follows.

Moreover, as methods for adjusting the amount of energy supplied, it is possible to vary the drive voltage[[,]] or to adjust the length of the heating. When changing the drive voltage itself, however, the structure of the circuitry tends to increase in scale, and

for this reason it is common to use a drive circuit for the heater and to change the heating period, thereby adjusting the amount of energy supplied.

The paragraph starting at page 6, line 8 has been amended as follows.

Additionally, in the recording head described above, the ink is discharged from the nozzle using heat generated by passing an electric current through the heater, so the recording head also generates heat during the process of recording. This increase in the overall temperature of the head is one factor that causes the drive state of the head to fluctuate, and must be taken into account as an element that, together with the above-described recording density, determines the amount of drive energy. Furthermore, differences in individual nozzle performance arising from slight production variations, such as variation in heater resistance value from one nozzle to the next, can also have an effect on the discharge of the ink. Thus the drive state is determined by a wide variety of elements. What is described above represents only the most ~~typically~~ typical examples, with recording control being exercised by ~~a~~ the consideration of ~~all~~ these ~~many~~ factors to obtain the optimum drive state at any given time and adjust the amount of energy supplied accordingly, in order to obtain better-quality recording results.

The paragraph starting at page 7, line 6 has been amended as follows.

Additionally, as personal computers (hereinafter sometimes referred to simply as PCs) have become faster, it has become possible to more easily handle large volumes of color image data ~~more or less easily~~, such that it is preferable to process large amounts of data when recording color images as well. Furthermore, the increasing fineness of recording images and increasing speed of processing makes it necessary to process ever larger amounts of image data at high speed. Increasing the speed of the recording operation in a serial-type ink jet recording apparatus like that described above can be achieved by increasing the number of cycles during which ink is discharged from the nozzles and by increasing the number of nozzles on the recording head. Enhanced fineness of the recorded image can be achieved by packing the recording head nozzles more densely together. However, such configurations tend to result in increasing numbers of nozzles to be driven per unit of time, and by increasing the number of nozzles to be driven per unit of time the number of nozzles involved in discharging ink simultaneously also increases, resulting in an increase in fluctuations in the drive state due to recording density as described above.

The paragraph starting at page 9, line 26 has been amended as follows.

(1) It has not been possible to independently determine the voltage drop generated by the driving of the recording heads, ~~and~~ the amount of the pulse current voltage drop in the path of the power wiring for the recording head and the voltage drop due to the smooth drive current that changes relatively smoothly.

The paragraph starting at page 23, line 24 has been amended as follows.

A description will now be given of the ~~composition~~ construction of the ink jet recording apparatus according to the present embodiment, with reference to Fig. 3.

The paragraph starting at page 24, line 1 has been amended as follows.

Fig. 3 is a block diagram showing the functional ~~composition~~ construction of the ink jet recording apparatus according to the first embodiment of the present invention. In Fig. 3, the control unit 30 comprises a central processing unit (CPU) 31, a ROM 32 that stores a variety of data and programs that are executed by the CPU 31, a RAM 33-1 that temporarily stores a variety of data, and interface (I/F) circuit 34 that transfers data to and from a host unit 41 that is an external device, a motor control circuit 35 that rotatably drives the carriage drive motor 5 and the sheet feed motor 10, and a gate array 36 that is provided with a logic circuit that performs a variety of controls auxiliary to the operation of the CPU 31. The gate array 36 is provided with a head control block 37 that carries out control and drive of the discharge timing of the ink jet recording head 2 and a RAM 33-2. Reference numeral 39 denotes an electric power supply unit that supplies electrical power to the ink jet recording head apparatus as a whole.

The paragraph starting at page 30, line 12 has been amended as follows.

Fig. 5 is a block diagram illustrating a discharge circuit and a discharge control of a recording head of a recording apparatus according to the present embodiment. It should be noted that although the ink jet recording apparatus~~, though it~~ mounts four separate recording heads comprising Bk, C, M and Y (2-1 through 2-4) ~~recording heads~~, the operating principle of each of the recording heads is fundamentally the same, and so the description given here is limited to the recording head 2-1 (Bk).

The paragraph starting at page 32, line 11 has been amended as follows.

The inputting of a heat signal 373 to that group of nozzles for which data has been set and the block selected in accordance with the above-described sequence activates ~~that~~ the drive transistor 2-105 that is connected to ~~that~~ the AND circuit 2-104 for which the output condition is satisfied, that is, for which the block is selected and the recording data is "1", thus triggering the flow of a heat current to the heater resistor 2-106 of the corresponding nozzle. The heat signal 373 is ultimately used as a signal that drives the discharge drive transistors 2-105, controlling the timing of the discharge of ink from the nozzles. At the same time, in order to adjust the amount of energy supplied to the heater resistor (heating elements) 2-106, the heat signal 373 is used to control the heating time of the heater resistors 2-106.

The paragraph starting at page 44, line 5 has been amended as follows.

Similarly, in Fig. 11 ~~also~~, in addition to the count values (37-211, 37-212, 37-411, 37-413, 37-414, 37-415) from the above-described column counters 3711, as well as block counter 3720, temperature information (temp), which is obtained by using the A/D converter of the CPU 31 to read changes in the output voltage Vf of temperature sensor diodes mounted on the recording heads but not shown in the diagrams, ~~as well as~~ and head ranking information (rank), which is determined by slight differences between the recording heads in terms of heat element resistance, drive transistor ON resistance and so forth as written to EEPROMs (See Fig. 13) mounted on each recording head and as read by the CPU 31, are converted into numerical values and imparted to the heat timing controller 3701.

The paragraph starting at page 48, line 23 has been amended as follows.

By contrast, in the second embodiment described below, the black recording head and the color recording heads ~~are~~ all ~~given~~ have the same ~~composition~~ construction, and the drive condition of any one recording head is made to reflect the drive conditions of all the other recording heads.

The paragraph starting at page 52, line 17 has been amended as follows.

Fig. 14 is a block diagram showing the ~~composition~~ construction of a control circuit that controls the individual parts of an ink jet recording head according to a

third embodiment of the present invention. It should be noted that the ~~composition~~ construction of the ink jet recording head according to the third embodiment of the present invention is substantially identical to the preceding embodiments, and accordingly, the same parts are given the same reference number and a description thereof is omitted.

The paragraph starting at page 55, line 22 has been amended as follows.

Fig. 15 shows ~~a diagram showing~~ a drive circuit of the recording head of the third embodiment. Fig. 16 is a timing chart showing ~~a~~ drive timing of the recording head depicted in Fig. 15.

The paragraph starting at page 59, line 7 has been amended as follows.

When a voltage drop occurs, in order to supply the same amount of energy to all the heaters (recording elements) 2-106 of the recording head 2, it is necessary to lengthen the pulsewidth in order to compensate for the drop in voltage. Assuming that the recording apparatus is one that mounts one or more recording heads having one chip (that is, one head substrate), comprising 64 nozzles _ 4 colors, the recording head(s) being driven off a single electric power supply system, and the 64 nozzles of the chip being divided into eight blocks that are driven independently, then the number of nozzles that are driven simultaneously at any given time is 0-32, a figure arrived at by noting that the number of nozzles to be simultaneously driven is 8 nozzles per chip _ 4 chips. If,

moreover, the number of nozzles to be driven simultaneously at any given time is uniform in space as well as uniform in time with respect to the nozzle position of each chip, then when the number of nozzles to be driven simultaneously is "N", the electric power supply circuit can be though of as a parallel circuit consisting of N numbers of heaters 1-N connected in parallel as shown in Fig. 18.

The paragraph starting at page 61, line 27 has been amended as follows.

When the voltage drop that occurs with the simultaneous drive discharge of a plurality of recording elements is compensated for by the drive pulsewidth (the main heat pulsewidth), the relation between the number of nozzles driven simultaneously and the drive pulse is as depicted in Fig. 20.

The paragraph starting at page 70, line 16 has been amended as follows.

First, the table shown in Fig. 26 is searched and, based on the head index and recording head 2 temperature, the temperature-linked pulse No. is determined (in step S303 in Fig. 25). Next, using the determined pulse No. ~~so determined~~ as a key, the table shown in Fig. 27 is referenced and the intervals Pt00, PT01 and PTM00 are set (in step S304). Finally, using the temperature-linked pulse No. as a key, the table shown in Fig. 28 is searched and a PT02 consisting of the above-described 30 ranks of total voltage drops

"Vdown" is selected and set as the PT02 selection table. The PT02 selection table set is used to determine the PT02 interval in the block trigger signal "Trig" introduction timing.

The paragraph starting at page 74, line 12 has been amended as follows.

The fourth embodiment is described with reference to a recording head having a ~~composition~~ construction consisting of a plurality of chips (that is, head substrates) and provided with an independent wiring region and a joint wiring region, in which the voltage drop of each of the chips due to the pulse current is determined independently so as to effect appropriate pulse control.

The paragraph starting at page 80, line 21 has been amended as follows.

Fig. 37 is a block diagram illustrating a voltage drop compensation process using a heat pulse according to a fifth embodiment of the present invention. It should be noted that, for identical ~~compositional~~ elements, Fig. 37 employs the same reference numbers as those used to describe the third embodiment with reference to Fig. 22, and a detailed description thereof is omitted. Here, only the ~~essential and~~ distinctive elements of the fifth embodiment are described.

The paragraph starting at page 84, line 23 has been amended as follows.

The above-described embodiments, particularly when used in ink jet recording systems, are capable of achieving high-density, highly detailed recordings by using a ~~scheme~~ process in which a thermal energy-generating means (such ~~as, for example,~~ as an electrothermal transducer) for providing the energy used to discharge the ink is used to cause changes in the state of the ink.

The paragraph starting at page 87, line 21 has been amended as follows.

The print head may be of the replaceable ~~tip-type~~ chip-type, in which the connection to the apparatus and the supply of ink from the apparatus can be achieved by mounting the head on the apparatus, or of the cartridge type, in which the head itself is integrally provided with an ink tank.

The paragraph starting at page 89, line 8 has been amended as follows.

The present invention can be applied to a system ~~constituted by~~ comprising a plurality of devices (e.g., a host computer, interface, reader, printer, etc.) or to an apparatus comprising a single device (.e.g., a copier or facsimile machine, etc.).